DELIVERABLE 3.2.1

FOOD MICRO SYSTEMS

REPORT ON EXISTING LITERATURE REGARDING CONSUMERS' PERCEPTION

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FoodMicroSystems aims at initiating the implementation of microsystems & smart miniaturised systems in the food sector by improving cooperation between suppliers and users of microsystems for food/beverage quality and safety.

The project runs from September 2011 to August 2013, it involves nine partners and is coordinated by ACTIA (Association de Coordination Technique pour l'Industrie Agro Alimentaire, France). More information on the project can be found at http://www.foodmicrosystems.eu.

Update notification

After discussion within the consortium it has been decided to add a paragraph on the potential of allergy control to this report. The current updated report presents this additional paragraph (April 2013).

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1 Introduction

Food-microsystems are the result of a development were interactive micro- and nano-systems are being applied in the control of food production, food production chains, and in relation to final products. Food microsystems is one of the areas of developing technologies where domains of ICT and life science start to converge (Roco & Bainbridge, 2002).

The development and application of emerging technologies has been shown to be, to some extent, contingent upon societal responses to those technologies and their applications (see for example: Cameron, 2006; Frewer et al., 2004), and nanotechnologies have been listed as a technology where societal response are likely to have an impact on the success or failure of the applications (The Royal Society & The Royal Academy of Engineering, 2004).

Food products appear to be particularly susceptible to citizen and consumer concerns, perhaps because authenticity (Skuras & Dimara, 2004) and unnaturalness (Lähteenmäki et al., 2010; Ronteltap & Van Trijp, 2007) are considered very important in the cognitive structure participants create for food products (Fife-Schaw & Rowe, 1996, 2000) Citizen and consumer protest has, for example, acted as a barrier to the successful application and commercialization of genetically modified organisms in many parts of the world (see e.g., Devos, Reheul, De Waele, & Van Speybroeck, 2006; Frewer & Shepherd, 1995; Gaskell et al., 2004; Gaskell, Bauer, Durant, & Allum, 1999). Besides the introduction of genetic modification, the food domain has focused on public response towards other novel technologies including high pressure sterilization (Sorenson & Henchion, 2011) and nanotechnology (Cook & Fairweather, 2007; Frewer, Fischer, & Rowe, 2010; Gupta, Fischer, Van der Lans, & Frewer, 2012; Siegrist, Cousin, Kastenholz, & Wiek, 2007; Siegrist, Stampfli, Kastenholz, & Keller, 2008). Understanding the formation of public response to emerging technologies is therefore considered an integral part of developing a successful research and governance strategy with regard to novel food technologies (Ward & Barnes, 2001).

The societal acceptance of ICT applications has also been studied. In general, the acceptance of ICT applications is most frequently studied in a context where acceptance is related to the usability of the application (e.g. Aoki & Downes, 2003; Coursaris, Hassanein, Head, & Bontis, 2012; Melenhorst, Rogers, & Bouwhuis, 2006), besides more societal concerns such as privacy issues (Joinson, Reips, Buchanan, & Schofield, 2010; Mahrous, 2011; Nepomuceno, Laroche, Richard, & Eggert, 2012; Whipple, Allgood, & Larue, 2012) and radiation and other effects of establishing a mobile phone network (e.g. Burgess, 2002; Van Kleef, Fischer, Khan, & Frewer, 2010).

The aim of the current report is to align the main approaches from societal acceptance of food technologies and those of interactive systems; and find and interpret the evidence on societal response to interactive food-microsystems in that framework; to the extent the literature is available.

2 Methodology

This report adopts a two-step approach. First the main models and approaches for societal acceptance of food and ICT technologies will be sketched based on existing theoretical papers in the scientific literature.
Subsequently, examples of smart food-microsystems will be looked for and interpreted against those approaches and frameworks, leading to suggestions for smart food-microsystems where possible and the identification of knowledge gaps where this information is not present.

3 Overview of the Literature

In a recent review on societal acceptance of nanotechnology, Ronteltap and colleagues, identified two distinct groups of approaches in the study into societal acceptance of new technology (Ronteltap, Fischer, & Tobi, 2011).

The first type of approaches, centres on risk and benefit perception and tends to investigate the larger societal consequences of a new technology in the context of abstract personal risks and benefits.
The second type of approaches, centres on the usability of an application and positions the potential and concrete personal benefits as more central to the analysis, with the larger societal embedding more distal.

This difference in approaches observed by Ronteltap and colleagues (2011) is particularly relevant in the context of smart microsystems in food, as Ronteltap shows that the first approach, focussing on risk and benefit perception, is dominant in the literature on acceptance of new food technology, while the second type of approach, emphasising ease of use, usefulness and usability is the dominant school for ICT applications. This makes a synthesis between both schools of research relevant to the current project, where food and ICT innovation converge.

Yet, as Ronteltap (2011) notices little to no connections are made at present, although some overlap in determinants and approaches exist between technologies (Gupta, Fischer, & Frewer, 2012) the operationalization and core assumptions behind the two approaches remain distinct. To investigate the need and potential of such connections, and interpret research into acceptance of food microsystems in the context, an overview of the core ideas in the approaches to new technology acceptance in food and ICT acceptance will be provided.

3.1 Approaches to acceptance of new technology in foods: Risks and Benefits

In a landmark paper in the late 1960's, it was revealed that the public acceptance of technologies is based on their *perceived* risks and benefits (Starr, 1969). These perceptions of risks and benefit differ systematically from a mechanical weighing of the assessed risk and benefit measures. It was shown that, among other factors, the voluntariness of the taken risk determined whether people were likely to accept the risk. This paper showed that non-technical elements of risk do determine whether the public is willing to accept these risks. Further investigation of drivers of risk perception resulted in the seminal work by Paul Slovic and colleagues between the late 1970's and the early 1990's, where it was shown repeatedly that properties of a technology that are *unknown* and *new to the public* increase risk perceptions, as well as technologies that are characterised by dreaded risks that are *catastrophic*, *fatal* and *uncontrollable* (Fischhoff, Slovic, & Lichtenstein, 1978; Slovic, 1987, 1992). This approach, labelled the psychometric approach, relies on constructing a mental model of the cognitive structure in which participants classify applications of new technologies. The psychometric approach has shown to be robust for power chemical risks (Slovic et al., 1995), medicine (Slovic, Kraus, Lappe, & Major, 1991), and is applicable for food technologies (Fife-Schaw & Rowe, 1996, 2000; Siegrist & Cvetkovich, 2001) and nanotechnology applications (Siegrist, Keller, Kastenholz, Frey, & Wiek, 2007). Although the psychometric approach has raised a numbers of objections, particularly related to explained variance and specificity (Sjöberg, 2002) and discriminative power between expert and lay perceptions (Rowe & Wright, 2001), individualised versions of the psychometric paradigm remain an important and relevant method in understanding the structure of risk perceptions (Siegrist, Keller, & Kiers, 2005). In addition, the psychometric study of risk perception has identified consistent predictors of risk perception such as food neophobia (Pliner & Hobden, 1992). The downside of the psychometric approach is that there is limited convergence across technologies as each technology brings its own risk benefit characteristics that are organised into unique mental maps for individual technologies. Thus, while the larger determinants (dread, newness) are consistently found, the specific dimensions may sometimes differ according to sample, application and operationalization of the research. This makes it necessary to construct a new mental map and determine unique position of an application in a bottom up fashion with every application of the technology.

At the higher aggregation level of risk perception and benefit perception, the literature on risk and benefit perception, has yielded some more generally applicable principles on the mental processes linking risk and benefit perception. This research was based on the somewhat unexpected realisation that empirically measured scores for risk and benefit perceptions towards existing products and technologies are negatively correlated (Alhakami & Slovic, 1994). This is surprising, as for successful products it stands to reason that high risks need to be compensated by higher benefits (i.e. show a positive correlation between risks and benefits); while the perceptions of high risk systematically co-occur with perception of low benefit (Finucane, Alhakami, Slovic, & Johnson, 2000). It was suggested that this underlying

connection between risk and benefit should be related to a connecting psychological construct. This construct cannot be a rational weighing of risks and benefits (as that would result in a positive correlation between risk and benefit perception). This connection, therefore, has to take the form of a heuristic. Affect (a primary emotional feeling) has been suggested as that heuristic replacing a more rational weighing of risk benefit evaluations (Finucane, et al., 2000; Siegrist, Keller, & Cousin, 2006; Slovic, Finucane, Peters, & MacGregor, 2002a, 2002b, 2004). Alternative approaches are less extreme and suggest that affect has an additive effect beyond rational weighing of risk and benefits, but does not replace that rational weighing (Loewenstein, Weber, Hsee, & Welch, 2001).
An alternative hypothesis is that trust is the single heuristic connecting risk and benefit perceptions (Siegrist, 1999, 2000; Siegrist, Gutscher, & Earle, 2005); or that trust in combination with affect operates as heuristic connecting risk and benefit (Siegrist, Cousin, et al., 2007). The role of trust as a causal agent for the perceptions of risks and benefit is somewhat disputed (Fife-Schaw, Barnett, Chenoweth, Morrison, & Lundéhn, 2008), as there is evidence that trust, risk perception and benefit perception are all dependent on the same single underlying heuristic, and that prior experience with a similar product or technology, more than anything else, colours perception of risk, benefit, as well as the trust placed in an agent communicating about the technology (Eiser, Miles, & Frewer, 2002; Poortinga & Pidgeon, 2004, 2005, 2006b).

Research within the risk-benefit perception approach has emphasised risk. Since the mid 1990's more attention has been paid to the role of benefit perception next to risk perception (Alhakami & Slovic, 1994; Frewer, Howard, & Shepherd, 1997). From the early 2000's the role of benefit perception has been more systematically included in the studies within the approach (see e.g. Saba & Messina, 2003; Siegrist, Cvetkovich, & Roth, 2000). Research is now starting to observe differences between the more general or societal risk and benefits and personal risks and benefits. This shows a pattern congruent with the long standing realisation that personal risks are consistently rated as smaller than societal risks (Frewer, Howard, Hedderley, & Shepherd, 1998; Klein & Helweg-Larsen, 2002; Miles & Scaife, 2003; Weinstein, 1980, 1989). In addition, it is becoming increasingly clear that personally relevant benefits have specific predictive potential beyond the more general risk and benefit perceptions (Ronteltap, van Trijp, & Renes, 2009; Schenk et al., 2008; Schenk et al., 2011).

The main predicted variable is often acceptance or attitude. In that context, it is of note to notice that secondary dimensions of attitude are increasingly considered of importance. This included attitude stability (Fischer & Frewer, 2009) where attitudes based on little knowledge are more likely to change, and ambivalence (Fischer, Van Dijk, De Jonge, Rowe, & Frewer, in press; Kahan, Braman, Slovic, Gastil, & Cohen, 2009; Poortinga & Pidgeon, 2006a) where people see both positive and negative elements of a situation at the same time.

It is of note to realise that while this approach is dominant in the acceptance of food technologies, some of these ideas have also been applied to ICT applications, most notably towards mobile telephones and their base stations (Siegrist, et al., 2006; Van Kleef, et al., 2010).

3.2 Approaches to acceptance of new technology in ICT: Ease of use and Usefulness of applications

With the emergence of more ubiquitous ICT applications aimed at lay users in the late 1980's, it became important to consider when the public accepts such applications. An important step was made by distinguishing perceived usefulness and perceived ease of use as important determinants in forming an attitude or evaluation of the technology, which in terms leads to an intention to use the system and to actual use (Davis, 1989).

This technology acceptance model (TAM), adopts parts of the highly influential theory of reasoned action (Fishbein & Ajzen, 1975) and its successor, the theory of planned behaviour (Ajzen, 1991). The technology acceptance model has further been expanded with more detailed determinants for perceived usefulness (Venkatesh & Davis, 1996) This TAM2 (Venkatesh & Davis, 2000); includes more detailed evaluations of the quality of the interaction (such as output quality and job relevance) but also normative influences, adopted from the theory of reasoned action, and experience, and voluntariness of use, constructs related to the psychometric paradigm (Slovic, 1987). A variation on the technology acceptance model, "the unified theory of the acceptance and use of technology" (Venkatesh, Morris, Davis, & Davis, 2003) aims to integrate socio-demographic insights from the diffusion of innovations theory (Rogers, 1962/1995), that add dimensions beyond those included in either the original technology model, the theory of reasoned action, or psychometric approaches to risk-benefit perception. A third version of the technology acceptance (Venkatesh & Bala, 2008) model includes determinants of perceived of success of use related to perceived behavioural control from the theory of planned behaviour (Ajzen, 1991) (computer self-efficacy, perception of external control); as well as emotional determinants of technology acceptance (anxiety, playfulness, enjoyment) related to the affective attitude dimensions (Crites, Fabrigar, & Petty, 1994). This may be related to end-user satisfaction as specified in the Usability guidelines (ISO9421-11 part 11: Guidance on the usability specification of measures, 1997).

The major benefit of these theories and models is that they have provided a more focussed way to study the acceptance of new technologies. As the measured psychological constructs are often operationalized in fairly similar ways, and there is a clear linear causal structure through the models these models have allowed for meta-analytic data aggregation (Armitage & Conner, 2000; Rivis & Sheeran, 2003), which has been shown to be much more problematic for the risk-benefit perception literature because of the less formalised measures in that literature (Frewer et al., in press).

There are, however, a number of caveats to the rigorous structuring of mental processes in this way. These relate to some of the key assumptions that underlie the theory of planned behaviour, and the very much related technology acceptance. As the theory of planned behaviour is in much wider use, it has been scrutinised across more different fields and attracted more criticism over the years.
While meta-analysis of the theory of planned behaviour shows a remarkable consistency in the prediction of behavioural intention, (Armitage & Conner, 2000) the predictive power of intention on actual behaviour is often limited, there is an *intention behaviour gap* (Sheeran, 2002).
The inclusion of experience from the second version of the technology acceptance model (Venkatesh & Davis, 2000) onwards introduces a feedback loop into the model (at least implicitly) as experience changes with repeated use. The changes on acceptance and behaviour are then likely become part of a self-regulatory system (Carver & Scheier, 1998; Higgins, Shah, & Friedman, 1997), where emotional steering signals become part of unconscious optimisation of behaviour towards its goals (Fischer, Blommaert, & Midden, 2005). In this way, the appealing simplicity of the technology acceptance model in the model being linear, with a clear starting and ending point, is transformed into a circular model, where ever increasing/changing experience and habit become important predictors of future behaviour (Aarts & Dijksterhuis, 2000). Although Ajzen has argued these effect may be captured in attitude, for example as attitude strength (Ajzen, 2001), more recently Ajzen has acknowledged (Ajzen, 2011), that repeated usage may indeed lead to automation of behaviour and thus render the choice outside the scope of what can be predicted in the context of a linear model for planned behaviour.
A second issue related to the theory of planned behaviour, relates to the level where conscious control over behaviour, i.e. the actual of the behaviour is always relevant or necessary. Emotion guided behaviours are often faster and more successful than planned behaviours (Bechara, Damasio, Tranel, & Damasio, 1997; Damasio, 1994; Peters & Slovic, 2000). Neurological evidence show that other brain areas are involved in such regulation of behaviour (Damasio, 1994; LeDoux, 2000). This renders the elaborate weighing of beliefs and preferences in the theory of planned behaviour, and the variants of the technology acceptance model a less than perfect representation of the actual brain processes (Ajzen, 2011). Arguments have been made that other, unconscious (Dijksterhuis & Smith, 2005) or associative thought processes (e.g. Greenwald et al., 2002) are predictive or at least contribute to decision to choose a certain option.
This effect relates to the actual decision process, and thus goes beyond the contribution of heuristic processes to attitude formation and change (Chaiken, 1980; Petty & Cacioppo, 1986). Instead, current researchers assume the existence of two different systems for reasoning (Kahneman, 2003; Sloman, 1996), which express themselves differently and interact (Gawronski & Bodenhausen, 2006, 2011). The heuristic and emotional systems become dominant if the task complexity or the choice context hinders elaborate processing (Kahneman, 2003; Petty & Wegener, 1999). Technology acceptance models are based on the elaborate system of belief formation which is only relevant in situations where people are motivated and capable of processing the relevant information. The adoption of ICT applications may

arguably conform to these condition more often than the purchase of foods, as the public tends to be more involved in novel ICT applications (such as the I-phone) and willing to spend time to figure out its function, compared to daily foods.

In spite of these criticism, the theory of planned behaviour is frequently used in the domain of food (Conner, Povey, Sparks, James, & Shepherd, 2003) where it is argued that the theory of planned behaviour is relevant after correcting for effects of impulsiveness (Churchill, Jessop, & Sparks, 2008), and it is argued that many of the problems with the predictive power of actual behaviour through the theory of planned can be solved by eliminating methodological imperfections in measuring attitude and intention (Kaiser, Schultz, & Scheuthle, 2007). Elements of the technology acceptance model have been applied in the domain of food in a study on the adoption of personalised nutrition (Ronteltap, van Trijp, Renes, & Frewer, 2007).

3.3 Comparing the approaches

The analysis of the literature above shows the different approaches and different histories of the development of these approaches. There are, however, properties to the technologies and the way society deals with their consequences that may have strengthened the development of these differing approaches.

The risk-benefit approach is most frequently applied to “facilitating technologies”, the technologies that allow the creation of new end-user products and services or improved marketing chains, but that do not explicitly deliver unique and novel benefits to end-users. Examples where this approach has been adopted include nuclear power generation (Siegrist, et al., 2006; Slovic, Flynn, & Layman, 1991), mobile telephony base-stations and the radiation of base station and handsets (Siegrist, Earle, Gutscher, & Keller, 2005; Siegrist, et al., 2006; Van Kleef, et al., 2010), hydrogen as energy carrier (Montijn-Dorgelo & Midden, 2008), genetic modification of foods (Frewer, 2003) and nanotechnology (Gupta, Fischer, & Frewer, 2012). All these technologies have in common that they facilitate end user behaviour indirectly (by providing electricity, a telephone network, power for cars, variants on food products, and myriad nanotechnology applications). The end user may not know, or may not care that the technology is central in the background, as long as the service operator provides the service and the end user is not bothered by the consequences it should be fine.
Ease of use and usefulness on the other hand; come to the fore, when the end user is confronted with a new product or service, which is clearly and visibly linked to the new technology. Examples include E-shopping and the internet (Perea Y Monsuwé, Dellaert, & De Ruyter, 2004), or smart phone services linked with QR codes (Shin, Jung, & Chang, 2012). In this case, the benefits of the technology are obvious to the end-user, and the user will more easily realise the necessity of the technology to reap the benefits of the new application.

The first approach has traditionally adopted a line of research aiming at reducing and controlling risk perception and providing risk communication, for technologies implemented outside the locus of control of the public (see e.g. Bostrom, 2003;

Fischhoff, 1995; Frewer, 1999; Frewer, Howard, Hedderley, & Shepherd, 1997; Gurabardhi, Gutteling, & Kuttschreuter, 2004; Neuwirth, Dunwoody, & Griffin, 2000). Thus this tradition has been rooted in risk analysis and protection of society against risks. The second tradition is more rooted in marketing where benefits are considered decisive for consumer purchase (e.g. Melenhorst, et al., 2006), which is more closely related to classical marketing approaches (such as the aforementioned TPB Ajzen, 1991).

These differences have deeper psychological consequences that can be framed in the context of two theories of consumer psychology that have attracted a lot of attention in the last 2 decades.
Construal level theories (Liberman, Trope, & Wakslak, 2007; Nussbaum, Trope, & Liberman, 2003); bring together a number of effects in social psychology by positing that there are basically two ways people construe a representation of the world, a high level or a low level construal (Eyal, Liberman, & Trope, 2008; Fujita, Henderson, Eng, Trope, & Liberman, 2006; Trope, Liberman, & Wakslak, 2007). A low level construal compared to a high level construal is characterised by (among others) a situation that is concrete rather than abstract, certain instead of hypothetical, close to the person rather than at societal level, close in time rather than in the future, can be imagined in a visual way rather than as a text. The uncertainty associated with risks, tends to set risk perception at a high construal level (Van Veggel, Ronteltap, Voordouw, Stijnen, & Fischer, submitted). Adopting construal level theories, facilitating technologies are thus more likely to be construed at a high level and associated with risk and uncertainty, while consumer directed application of technology would be construed at low level. Products that are concrete and can be held in hand for immediate use (like a mobile phone or a laptop) are more likely to be construed at a low level.

The emphasis on risk for facilitating and benefits for concrete applications may have further consequences for the public view on these different applications, if we consider that people have two ways to optimise behaviour (1) avoid negative situations, and (2) approach positive situations. These regulatory tendencies lead to different types of dealing with the situation (Higgins, 2000; Higgins, et al., 1997), after all, when approaching a goal, there is only one desired end state (close to the goal – i.e. focussed direction), while when avoiding negative consequences, every outcome is fine, except that what we avoid (unfocussed). Consumer actions and opinions are then becoming coloured by a "regulatory fit" between the situation and the type of decision that is being taken (Higgins & Scholer, 2009; Scholer & Higgins, 2009). In the context of these technologies, avoidance of risks seems the more fitting strategies for the abstract facilitating technologies associated with risk, while benefit approach is the more likely way end user look at concrete lowly construed technological innovations.

3.4 Interpretation of smart food microsystems against the literature

Consumer perception of smart food microsystems remains largely unstudied with the exception of RFID tagging and smart packaging, where some papers have been forthcoming.

The more dominant topic is the introduction of RFID tags, which has raised considerable interest from 2005 onwards, including in the food sector (Jones, Clarke-Hill, Comfort, Hillier, & Shears, 2005). Major concerns about the use of RFID has centred on the perception that this technology would allow post purchase tracking of consumers (Slettemeås, 2009) leading to undetectable privacy violating in the idea of many consumers (Chen, 2009).Main determinants that have driven consumer perceptions of RFID applications were privacy concerns and trust in the retailer (Beitelspacher, Hansen, Johnston, & Deitz, 2012). These studies imply that the determinants for acceptance of RFID technology are currently found in the risk-benefit approaches to societal acceptance. A study using the Technology Acceptance Model also flagged up the societal determinants in the TAM, rather than the attributes central to the functionality of ease of use and usefulness as predictive for acceptance (Ravasan & Soorkali, 2012). This provides further supports that the public at present uses a general risk frame to evaluate general RFID applications. On the other hand, when more specific, consumer oriented applications of RFID are studied, such as in the case of the combination of RFID technology with a smart refrigerator, consumers are more positive as they see concrete benefits related to convenience, stock management and even designing healthier diets (Heiskanen et al., 2007). Although Heiskanen also observed some negative perceptions towards this application, interestingly privacy concerns were not among those.

Another application of smart food microsystems where consumer acceptance is considered an issue revolves around smart packaging (Bryksa & Yada, 2012; Kerry, O'Grady, & Hogan, 2006), or actively communicating packages (Angehrn, 2009). The evidence of clear consumer benefits from communicative smart packages in choosing products (Kampers, 2011). Consumer expects benefits of communicative packaging both in retail and for catering situations (Heiskanen, et al., 2007). Consumers did voice concerns however, that these communicating packages could reduce capacity of consumer to judge food quality (Heiskanen, et al., 2007) and that it might lead to even more food waste as shops may remove product with discolouring labels before a safe to use by date is reached (Van Veggel, et al., submitted). Also the potential of fraud (Van Veggel, et al., submitted) and additional chemicals to be released into the environment with discarding the packaging (Van Veggel, et al., submitted) were considered potential problems with these packages. Finally, consumers thought most of the benefits would go to retail (Heiskanen, et al., 2007), with the added price for the packaging leading to higher priced products (Van Veggel, et al., submitted). Against, this it needs to be noticed that within retail marketing, RFID and smart packaging are considered to have great potential to optimise fresh assortment to consumer demand, and it is recognised this will involve redesigning important elements of the retail concept as a whole (Sorescu, Frambach, Singh, Rangaswamy, & Bridges, 2011).

Where RFID applications tend to be considered with some suspicion related to privacy, and some mild hopes for better food; smart packaging is considered as a consumer benefit, with some relatively minor concerns for the environment, and the social equity of distribution of benefits.

From the current analysis it is interesting to note, that risks are in general construed at higher abstraction level and more socially and temporally removed, while the benefits are indeed construed more concretely and immediately. The reviewed papers also show that depending on characteristics of the presented application, and the scenario provided, smart food microsystems can be studied within the concepts of both approaches; that of risk-benefit perception, and that of ease of use and usefulness.

Novel products and production technologies in food production have to be considered in the light of food allergies and intolerances. From the point of view of the consumer, allergies and intolerances are the same (Van Putten et al., 2006) and cause for concern in relation to novel technologies in food. Issue involving food allergies may arise from food microsystems on several levels. Consumers may perceive that materials used with micro technology may cause complaints. The use of biomaterials (such as proteins) in online testing equipment, e.g. electronic nose, or lab on a chip, may potentially lead to actual allergic complaints; while the use of plastics and metals approved for food production should not be a major problem, although these materials may have unanticipated effects if they end up in food as nanoparticles. Regardless of physical allergenic properties, consumers may perceive that the materials used may either result in substances in the food, or contaminate the food through mere contact (cf Rozin, Fallon, & Augustoni-Ziskind, 1985; Rozin & Fallon, 1987). Even when the actual contamination is not present, or no allergic complaints are known about these materials, this may still lead to a negative public opinion.
Against this, the introduction of microsystems may support detection of allergenic substances as well. At the moment, products from production lines and processes that may (but not necessarily do) involve contact with allergenic substances are routinely labelled with end-user warnings (such as: ”May contain traces of nuts”). From the point of view of the allergic consumer these warnings severely limit their freedom of choice, and reduce their potential of a normal diet (Voordouw et al., 2009; Voordouw et al., 2010). In the context of ever changing formula’s (“New recipe”), a broad range of allergens that differentially affect patients, information is not available in the right level of detail on the package for all allergic consumers (Voordouw, et al., 2009). Consumer indicated that they would be helped in their food choice if detailed and patient specific information could be made available through a handheld ICT device/scanner linking label codes to a detailed online ingredient list (Voordouw et al., 2012). Food microsystems may supports this demand in three ways. Implementation of a broad range of allergen scanners in the

process stage. The smart micro system in itself will in these case not reach the consumer. If production codes would be made available on the package as a QR-code to be scanned through a smartphone application, or an RFID chip relating a product to this information. In these cases, allergic consumers could access specific allergy information for a specific batch of produce, tailored to their individual allergies. A second way of communicating this information may be through an active package, that can "sniff" out allergens inside the specific product, and communicate these eithers visibly on the package or through a transmitter like an RFID chip. This appears futuristic as the packaging should contain detectors for a broad of allergens while being very cheap at the same time. Finally, food microsystems might be used to construct a "hometesting" kit, where allergic consumers can test food products for a specific set of allergens. This would, however, require the construction of safe, robust and user friendly equipment aimed at a small target audience.

Altogether it appears that food microsystems could both create and mitigate concern about allergies. A very thorough weighing of which benefits and risks accrue to whom, and whether the choice to benefit some at the possible expense of others (either perceived or real does not matter in this case) is necessary to arrive at an ethical way forward (van Putten et al., 2011). It should be kept in mind that for the public, only perceptions matters, and that this is only partially related to expert knowledge.

4 Discussion and conclusions

The current review has provided a framework to analyse consumer opinion against two different approaches of technology acceptance, relevant to food and ICT. The review has aimed to align two approaches which are not usually combined.

Based on the very limited specific information on smart microsystems applied to food we conclude.

- It is not clear which of the theoretical approaches or what synthesis between the approaches will best fit consumer response to food microsystems: the food risk approach, or the ICT technology acceptance approach.
- It is clear that depending on specific application and framing in which it is presented, elements of both the approaches will be important.
- The current situation underlines the need for convergence in social sciences approaches to new technology acceptance recently voiced (Ronteltap, et al., 2011); and goes beyond that position in showing that depending on construal level, and regulatory fit, both approaches can provide relevant input in understanding consumer acceptance of smart food microsystems.
- There is a lack of data on different situations in which Food Micro systems can be framed, makes conclusion specific for smart food microsystems speculative.

- Issues of risk, benefit and trust emerge as consistent determinants for public acceptance of novel technology. The exact determinants of risk, benefit and trust, however seem to context and technology dependent.

To get better insights in what is really the case; more knowledge on consumer visions needs to be elicited.
As there is a distinction between two approaches, each having their own research paradigms, confirmatory techniques are likely to bias results to favour one of the approaches. Therefore this issue is best studied with qualitative techniques at this stage, to evaluate the relevance of the existing approaches (cf. the empirical cycle de Groot, 1969). The focus groups reported in Deliverable 3.2.2 will provide data of this type.

Within the on-going project the current review delivers insights in the complexity of consumer deliberation on novel technologies and to provide a yardstick against which to interpret the outcomes from the focus groups.

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